CHAPTER VI

EFFECTS OF NICOTINE THAT MAY PROMOTE TOBACCO USE

CONTENTS

Despite the well-known health hazards associated with cigarette smoking and tobacco use, more than 50 million Americans continue to use these products. (See Chapter I for a brief review of health hazards and Appendix A for prevalence of use data.) Chapter IV presents evidence that tobacco use is an orderly form of drug-seeking behavior that involves nicotine self-administration. It is clear from Chapter IV that tobacco use involves several biobehavioral processes of drug dependence, including nicotine reinforcement and withdrawal. The initiation and maintenance of this dependence process may be promoted by other actions of nicotine. For example, some cigarette smokers report that smoking helps them to think better, to cope with stress, and to keep body weight under control. The fact that people believe that tobacco use has these effects may contribute to initiation, maintenance, and relapse.

This Chapter examines the evidence on the following three effects of nicotine:

- enhancement of human performance
- control of stress responses
- control of body weight.

These particular topics are presented because there is scientific literature relevant to each topic and because nicotine has been suggested to be central to each of these effects.

The three topics are discussed separately in this Chapter because the substantive material and relevant data are distinctly different for each topic. Also, the research on each topic is at a markedly different evidentiary stage at this time. Whereas studies on nicotine and performance are intriguing, there are some serious methodological concerns that force caution in the interpretation of the available experimental investigations. In contrast, the relationship between stress and smoking (i.e., that stress increases smoking) is well documented by self-report data, and several investigators have offered detailed theoretical explanations and mechanisms to account for this phenomenon. However, much of this speculation has preceded experimental investigations. In still another stage of investigation, extensive data have been gathered on the relationship between cigarette smoking and body weight, and laboratory studies have carefully assessed the role of nicotine. Explanations for the relationship between nicotine and body weight are based on investigations that were designed to test specific variables involved in this relationship. All three topics are currently receiving research attention and are considered to be important areas for more extensive investigation. This Chapter is meant to complement the information presented in Chapter IV to provide a more complete understanding of tobacco use. Most of the studies discussed in this chapter have examined effects of cigarette smoking. Some studies present data on effects of nicotine alone. The similarity in findings of these two types of studies supports the conclusion that nicotine is responsible for the effects of cigarette smoking.

Tobacco Use, Nicotine, and Human Performance

Some cigarette smokers believe and report that smoking helps them to think and to concentrate (Russell, Peto, Patel 1974). These possibilities have been studied in the laboratory using several different tasks. Unfortunately, this research literature has methodological limitations. Most of the published studies compare smokers smoking with smokers not smoking. Few studies have included nonsmokers not smoking as a control group. When smokers smoking perform better than smokers not smoking, it is impossible to know if smoking actually improved performance, if abstinence from smoking impaired performance, or both. In addition, most studies allowing smoking and evaluating performance did not measure nicotine levels in the subjects. Therefore, the role of nicotine generally is inferred but not directly assessed. A few studies administered nicotine by oral tablets to smokers and to nonsmokers. This Section examines the effects of cigarette smoking and nicotine on attention, learning and memory, problem solving, and the control of motor function. Implications of these effects for tobacco use are discussed.

Attention

Effects of cigarette smoking on attention have been examined in the laboratory using sustained attention tasks, selective attention tests, and perceptual intrusion or distraction measures. The results using each measure are reviewed separately.

Sustained Attention

Vigilance tasks are the fundamental paradigm in the laboratory for defining sustained attention. Attention is directed to one or more sources of input for long periods of time. The subject is required to detect and respond to small, infrequent changes in the input. Performance in vigilance situations is often assessed in terms of the detection rate, i.e., the proportion of signals correctly detected, and the false-alarm rate, i.e., the number of occasions on which a signal is reported when one has not been presented. Measures of stimulus sensitivity and response criterion can be derived from the detection rate and the false alarm rate using the Theory of Signal Detectability (Green and Swets 1966) in order to assess performance. During a typical vigilance session, the detection rate decreases (the vigilance decrement), but it is also important to know if there is a decrease in false alarms, which would mean a criterion shift. If the rate at which a subject detects the stimuli falls, but there are no changes in false alarms, then there is a reduction in stimulus sensitivity.

In a study of smoking and visual vigilance, the Mackworth Clock (Mackworth 1950) was used because it produces a reliable vigilance decrement. Cigarette smokers who were allowed to smoke at 20-min intervals throughout the 80-min vigilance task maintained their stimulus sensitivity to experimental targets (Wesnes and Warburton 1978). In contrast, sensitivity was reported to drop for a group of nonsmokers and for a group of smokers who were not allowed to smoke. This finding suggests that smoking helped to maintain vigilance, but it could be that abstinence from smoking contributed to the performance decrement for smokers who were not allowed to smoke.

Tong and coworkers (1977) studied the performance of nonsmokers, smokers not smoking, and smokers smoking on a 60-min auditory vigilance task. While nonsmokers and smokers not smoking detected fewer signals as the test progressed, smokers smoking increased their number of detections. Again, it seems that smoking improved vigilance. However, this conclusion is tempered by the fact that the nonsmokers generally performed better than did the smokers on this task. Wesnes and Warburton (1978) reported that smokers maintained their initial level of stimulus sensitivity to auditory targets over an 80-min vigilance session when they smoked cigarettes at 20-min intervals. When they performed the task while smoking nicotine-free cigarettes, their sensitivity decreased over time. A similar study with a higher target density found a similar result: smoking was accompanied by maintained stimulus sensitivity (Mangan 1982). Whether smoking increased vigilance or whether abstinence decreased vigilance is not clear.

To determine whether nicotine was responsible for these effects of cigarette smoking on attention, Wesnes, Warburton, and Matz (1983) gave subjects nicotine tablets under the tongue and examined visual vigilance. The tablets consisted of nicotine placed on an alkaline matrix material to permit buccal absorption. Nicotine helped reduce the vigilance decrement by maintaining stimulus sensitivity. The nicotine tablets produced the same effects in nonsmokers, light smokers, and heavy smokers (Wesnes, Warburton, Matz 1983). Wesnes and Warburton (1978) found a similar effect of nicotine tablets on smokers but found no effect on performance by nonsmokers. Wesnes and Warburton (1984b) reported a small improvement in performance by nonsmokers given 1.5-mg-nicotine tablets; 1.0-mg- and 0.5-mg-nicotine tablets did not improve performance.

The effects of smoking on sustained reaction time performance, which has a vigilance component, were studied by Frankenhaeuser and others (1971). The experimental sessions lasted 80 min during which subjects continually performed a simple visual reaction time test. In the nonsmoking condition, the speed of reaction decreased over time; in the smoking condition, there was little change over the session. Subjects abstained from smoking the night before participating in this study. Therefore, the smokers in the nonsmoking condition were deprived for many hours.

Wittenborn (1943) factor analyzed attention tests and found that picking out various sequences of numbers or letters from an array was most heavily loaded on what he called an "attention" or "mental concentration" factor. Williams (1980) assessed the effects of smoking by smokers on a test of this sort that involved crossing out each letter "E" found in sheets of randomly ordered letters arranged in lines of 30 letters. Smoking cigarettes produced significant improvement in performance of the letter cancellation task compared to sham smoking an unlit cigarette (Williams 1980). Because the subjects had abstained from smoking overnight before the experiment, it is not clear whether smoking improved performance or whether deprivation caused a decrease in performance.

A computer version of the letter crossing test is the Bakan task (Bakan 1959), in which a series of digits is presented at the rate of 1/sec from which subjects are required to detect certain specified three-digit sequences. Measures of both the speed and the accuracy of detection rate are made. Performance on this rapid visual information processing task after smoking was improved in both speed and accuracy above baseline levels, whereas either not smoking or smoking nicotine-free cigarettes resulted in a decline in speed and accuracy below baseline levels (Wesnes and Warburton 1983). The improvement in both speed and accuracy indicates that there is no speed and accuracy tradeoff. Higher-yield cigarettes improved performance more than low-yield ones, suggesting that nicotine is involved in these effects (Wesnes and Warburton 1984a). This interpretation is supported by studies with cigarettes with similar nicotine content but varying levels of tar and carbon monoxide (CO); cigarettes with the same nicotine content have the same effect on speed and accuracy (Warburton, in press). However, these conclusions must remain tentative until nicotine levels in the body are measured.

Analyses of performance during cigarette smoking indicate a 15-percent increase in speed and accuracy (Wesnes 1987) and improvement puff by puff (Warburton, in press). Rapid visual information processing has been studied during cigarette smoking puff by puff. Even with one puff, the probability of correct detections in the smoking conditions was higher than in the nonsmoking condition, and a single puff produced a change in reaction time (Warburton, in press). These findings suggest that smoking improves performance. However, these within-subject analyses need to be replicated and compared to nonsmoker control groups.

Selective Attention

Selective-attention tasks involve either focused or divided attention. Focused-attention tasks require subjects to attend to one source of information to the exclusion of others. Divided-attention tasks require subjects to divide their monitoring between two or more sources of information.

One study of selective attention (Tarriere and Hartemann 1964) combined central guiding with peripheral visual monitoring. The task lasted for 2.5 hr, and the measure of performance reported was the percentage of the peripheral visual signals that were missed during the session. Monitoring performance was maintained by smoking, in contrast to the large increase in the percentage of signal omissions when the subjects (all of whom were smokers) were not smoking.

In a study of divided attention, a test was based on the rapid visual information task (Warburton and Walters, in press; Wesnes and Warburton 1984a). Subjects were presented with digits at a rate of 50/min in both the visual and auditory modalities, with a different sequence for each modality. The detection of sequences in both parts of the divided attention task improved significantly after the smoking of one cigarette in comparison with not smoking. Smoking a cigarette also prevented the increase in reaction times that occurred in the control condition (smokers not smoking).

These studies show that smokers who smoke before selective attention tasks perform better than smokers who abstain from smoking before these tasks. Both the sustained and selective attention data indicate that smoking helps the smoker to perform.

Distraction

The Stroop test has been used in smoking research to examine distraction effects. The Stroop test uses three sets of displays: a list of color words printed in black, a set of color patches, and a list of color words with the words printed in incongruent colors (e.g., the word "Green" printed in blue). Subjects' word reading is faster than color naming, while naming the incongruently printed color words takes much longer than naming the patches. The time difference between naming the colors in the two conditions is the Stroop effect. This score indicates the subject's ability to focus attention on a relevant stimulus dimension of print color and to ignore an irrelevant semantic one.

The effects of nicotine on the Stroop performance of smokers and nonsmokers have been studied (Wesnes and Warburton 1978; Wesnes and Revell 1984). Wesnes and Warburton (1978) reported that nicotine reduced the size of the Stroop effect and that there were no differences between smokers and nonsmokers in the amount of improvement produced by nicotine. This finding supports the argument that the effects of nicotine on attention are similar in smokers and nonsmokers. However, only six smokers and six nonsmokers participated in this study. Also, the performance by nonsmokers was not improved by nicotine tablets in the Wesnes and Revell (1984) study. Therefore, conclusions must be tentative until the findings of Wesnes and Warburton (1978) are replicated.

Evidence from the few distraction studies that have been reported is consistent with the results for sustained and selective attention. It may be that smoking and nicotine improve a general attentional processing capacity including improved attention to relevant stimuli (sustained and selective attention data) and ability to disregard irrelevant stimuli (distraction data). However, until studies include nonsmoker control groups and measure nicotine levels in the body, the conclusion that smoking improves attention remains plausible but equivocal. It is reasonable to conclude that the attention of smokers is better after smoking than after deprivation from cigarettes.

Learning and Memory

Numerous animal studies have demonstrated that nicotine improves learning and memory when it is administered pretrial and posttrial (Bättig 1970; Bovet-Nitti 1965; Castellano 1976; Erickson 1971; Evangelista, Gattoni, Izquierdo 1970; Stripling and Alpern 1974; Szekely, Borsy, Kiraly 1974). The effects of smoking and nicotine on human learning and memory are surprisingly complex in comparison with the effects described in reports of animal studies. Some studies of the effects of smoking on human learning and memory have shown that smoking improves this aspect of mental ability (Mangan 1983; Mangan and Golding 1978; Warburton et al. 1986). Studies of the effects of pure nicotine on human learning and memory have shown that nicotine improves memory just as smoking does (Warburton et al. 1986). However, Hull (1924) found evidence of impairment in auditory memory and in the efficiency of rote learning immediately after smoking, and later studies also have found that smoking can interfere with learning and memory, especially immediate memory (Gonzales and Harris 1980). The effects of smoking and nicotine on learning, immediate memory, delayed recall, and state-dependent memory are addressed separately.

Learning

There is no evidence for improved acquisition of information (i.e., general learning) after smoking. For example, Carter (1974) reported a higher number of correct responses from 10 smoking subjects than from 10 nonsmoking subjects on a letter-digit substitution task for the second of 2 10-trial blocks given in the first 2 sessions (7 days apart). However, there was no difference between groups in savings (number of trials) for serial learning of a letter-digit substitution task.

Kleinman, Vaughn, and Christ (1973) had nonsmokers, 24-hr deprived smokers, and nondeprived smokers do paired-associate learning of a low- or high-meaningful list of nonsense syllables. There was no difference in learning among the groups on both trial and errors to a criterion. However, deprived smokers performed better on the high-meaningful list and worse on the low-meaningful list than did either of the other two groups.

The effects of nicotine on learning also have been investigated. Andersson and Post (1974) compared the effects of nicotine cigarettes with those of nicotine-free cigarettes in subjects learning a nonsense syllable list. Significant increases in heart rate indicated that nicotine was absorbed from the nicotine cigarettes. The first cigarette was given after the first 10 trials of learning the list, and a second cigarette, of the same kind, was given after 20 trials. The learning curves were identical for the two conditions prior to smoking. After nicotine, the number correct decreased and remained below the scores in the nicotine-free condition, but the learning curves were parallel. Thus, the rate of learning was not changed by smoking. After the second nicotine cigarette, the number of correct syllables increased significantly to the same level of acquisition performance as in the nicotine-free cigarette condition. Relative to the previous performance, nicotine had improved recall of the syllables. The difficulty in interpreting the effects of nicotine in this study is that learning and recall occurred over a 20-min period, while plasma and brain levels of nicotine would be expected to fall well below their peak levels. These data give no evidence of nicotine impairing acquisition, because the learning curves are parallel after the nicotine cigarette. However, it appeared that after the first nicotine cigarette, the information stored in the non-nicotine state was less available in the nicotine state, a phenomenon known as state-dependent learning. (See "State-Dependent Memory" below for a fuller discussion of this phenomenon.)

In another study, Andersson (1975) examined the effects of smoking on verbal rote learning using a similar procedure. Ten smokers were tested on two occasions during which they were initially given 10 successive trials followed by an 8-min break. In one condition, the subjects smoked a 2.1-mg-nicotine-delivery cigarette during this period, and in the other they simply rested. Then, another 10 trials took place, after which a 45-min break was given, followed by a final learning trial. As in the previous study, recall was significantly lower immediately after smoking. This lowered recall tended to recover on successive trials. After the 45-min break, the recall in the two conditions was again identical.

Immediate Memory

In a study of immediate memory (Williams 1980), subjects were tested within 15 min after smoking one cigarette. They were given lists of numbers to memorize and then were immediately asked to recall them in the correct sequence (constrained recall). No main effects were significant. Controlling for presmoking performance, the number of errors increased with strength of cigarettes smoked.

Houston, Schneider, and Jarvik (1978) had 23 heavy smokers, deprived of cigarettes for 3 hr, read a list of words. The subjects were matched on a free-recall test prior to smoking. Each member of one group smoked a 1.5-mg-nicotine cigarette, and each member of the other group smoked a non-nicotine cigarette. The subjects were given three lists with free recall tests after each one. The immediate recall scores showed that the nicotine group had significantly less recall than the placebo group did. When testing was given once just after the input, however, facilitation was seen (Warburton et al. 1986). After smoking a 1.4-mg-nicotine cigarette, each of these subjects was shown a list of nouns and immediately asked to write down as many as possible. Measures of immediate recall were improved in smokers after smoking compared with not smoking.

Comparison of Immediate and Delayed Recall

Gonzales and Harris (1980) assessed the effects of smoking or abstinence on immediate and delayed memory of new and old (previously presented) words, as well as category clustering. Smokers smoking showed significantly poorer immediate and delayed recall of old words and less clustering of words into categories on the delayed recall test as compared with smokers who were not allowed to smoke before the tasks.

Mangan (1983) examined the effects of smoking a low- (0.7 mg) and a middle- (1.3 mg) nicotine-yield cigarette on paired-associate and serial learning and retention. Conditions included high and low intralist interference. Cigarettes improved retention in paired-associate learning, with task difficulty apparently having little relevance. Smoking impeded learning under low-interference conditions, but facilitated learning of high-interference sets.

Mangan and Golding (1983) studied the effects on memory of smoking deprivation and of smoking a single cigarette immediately after acquisition of a paired-associate learning task. Subjects were retested for retention of the memorized material at intervals of 30 min, 1 day, 1 week, and 1 month. At 30-min retest, nonsmokers showed superior recall compared with all smokers. After 1 month, subjects who each smoked a low- and medium-nicotine cigarette were better than those who smoked high-nicotine cigarettes. They also achieved superior recall compared with nonsmokers.

Peeke and Peeke (1984) tested the effects of smoking one cigarette on verbal memory and attention in four experiments. In one study, subjects were allowed to smoke before the test ("pretrial smoking"), after the test ("posttrial smoking") or not at all ("no smoking"). Recall of a 50-word list was tested immediately after intervals of 10 and 45 min. Pretrial smoking resulted in improved recall 10 and 45 min after learning, but not immediately. Posttrial smoking was ineffectual. Tests at 1, 5, and 30 min after presentation of a 20-word list were compared with results from pretrial smoking. Improved recall occurred for pretrial smoking. The high-nicotine cigarette produced improved recall on both immediate- and delayed-recall tests. The low-nicotine cigarette was less effective. Light and heavy smokers did not differ in the effect of smoking on recall.

Andersson and Hockey (1977) presented words in different positions on a computer screen to smokers allowed to smoke or not allowed to smoke. In one condition, subjects had to remember the words in presentation order. In the second condition, subjects were asked to remember words, word order, and location. There were no differences between the smoking and no-smoking conditions in the percentage of words that were recalled in the correct order or for the percentage of words that were recalled correctly, regardless of word order. However, recall of position on the screen was poorer for the smoking group. When the subjects were asked to attend to all three aspects of the material, the groups did not differ significantly in their recall, although there was a trend for location to be recalled better after nicotine use than after deprivation. This study suggests that nicotine can enhance storage of information only if the subjects perceive that the information is relevant.

State-Dependent Memory

In a state-dependent design, one group of subjects learns after a dose of drug while a second group learns after a placebo or nothing. For the recall test both groups are divided: half of each group is tested with the agent presented during learning and half is switched to the other condition. If the recall scores are better for those groups that learned in the same chemical state, then state-dependent learning is said to have occurred. Numerous animal studies have provided evidence of state dependency with cholinergic drugs (Warburton 1977). The possibility that nicotine produces state-dependent learning in human subjects has been investigated in several studies.

Kunsendorf and Wigner (1985) examined state-dependent recall on text material. Subjects spent 15 min studying a 550-word article on education and answered 6 factual questions based on the article after a 10-min break. The treatment conditions were smoking versus no smoking during the study period and during testing. When studying and testing were conducted for the same subject state (either smoking or no smoking), memory was better than when study and testing were conducted for different states.

Other investigators also have found evidence for state-dependent learning with smoking. Peters and McGee (1982) used the state-dependent design to test smoking's effect on recall and recognition memory. After smoking a 1.4-mg-nicotine cigarette, each subject was shown a list of nouns and immediately asked to write down as many as possible. There was no evidence of any difference in immediate recall, a finding in agreement with Andersson and Hockey (1977) and Houston, Schneider, and Jarvik (1978). However, on the following day, there was a state-dependent effect on the recognition test but no difference between the same-state groups.

In another recognition study (Warburton et al. 1986), smokers who were deprived of cigarettes for more than 10 hr were each given a 1.4-mg-nicotine cigarette or nothing immediately before serial presentation of a set of Chinese characters. Subjects were divided into four equal groups: Those who did not smoke prior to learning or recall; those who did not smoke prior to learning, but had a cigarette prior to recall; those who had a cigarette prior to both learning and recall; and those who had a cigarette prior to learning, but none prior to recall. Subjects who smoked prior to learning had significantly better recognition scores than the subjects who did not smoke in the first part of the experiment. There was no effect of smoking on recall performance. A significant interaction term indicated that changing the chemical state interfered with recognition.

Warburton and colleagues (1980) used nicotine tablets in the state-dependent design. After ingesting the tablet, each subject listened to words and then performed successive subtractions for 1 min to prevent rehearsal. Immediate free recall was improved. One hour later, the subjects were given either nicotine or placebo tablets. They were asked to recall as many of the words as they could in another 10-min free recall test. Long-term recall was significantly better when subjects had taken nicotine prior to learning, but was not when taken prior to recall. A significant interaction term gave evidence for a state-dependent effect of nicotine and showed that nicotine was facilitating the input of information to storage, but had no direct effect on storage or retrieval.

These findings suggest that there is a state-dependent effect of smoking on cognitive performance. The seeming impairment of immediate memory, however, complicates any simple generalizations about smoking and memory or nicotine and memory. As with the attention literature, studies need to include nonsmokers as controls to determine whether smoking or abstinence from smoking affects learning or memory. In addition, task characteristics and individual differences among subjects must be considered in future investigations. Based on the available evidence, there are no clear effects of smoking on learning or memory.

Problem Solving

Human problem-solving capabilities involve both attention and memory. Attention is important because distraction from the task will cause a deterioration in problem-solving performance. Memory also plays a critical role in thought, both guiding the operations of the thought processes and limiting their power. Problems can be broadly categorized as well defined and ill defined. A well-defined problem has a clearly stated goal with a clear method to ascertain if the problem solving will lead to the correct solution. A well-defined problem can be solved by convergent thinking that produces logically correct answers. A simple example of a well-defined problem is addition. Ill-defined problems are solved by divergent thinking that leads to inventive solutions.

Hull (1924) found that smoking increased the rate of complex mental addition, but had no measurable effect on the accuracy of addition. Kucek (1975) found that the reduced efficiency of mental addition that was produced by doing a tracking task was ameliorated by smoking. The improvement was especially manifested in the most neurotic subjects. One interpretation of this improvement is that the attentional effects of nicotine enabled the filtering out of the distracted thoughts that interfered with performance.

A task that has elements of both convergent and divergent thinking is the Luchins Jar test (Luchins 1942), in which subjects are asked to solve a number of "numerical problems" involving the measurement of a quantity of water by means of a set of measuring jars. For the first six trials, exactly the same solution can be used, but after trial six, both the old formula and a new, easier formula are appropriate. A measure of convergent thinking is performance on the first six trials, while divergent thinking is assessed from the time taken to discover the new, easier solution. Smokers who were allowed to smoke performed better on the first half of the test in which subjects used the same solution repeatedly (convergent thinking), but were slower to change to a simpler solution when it was available, divergent thinking (Warburton 1987). While it could be argued that nicotine had impaired divergent thinking, it has been argued that it is more efficient for a subject to use a known strategy, no matter how clumsy it might be, than to attempt to invent a new one, i.e., to maintain attention (Norman 1980).

Motor Control

The effects of smoking on motor control were investigated in the early laboratory study of Hull (1924). He found a marked increase in hand tremor, a slight increase in resistance to muscular fatigue and in speed of reading reaction time, and no measurable effect on the rate of tapping or on the rate or accuracy of eye–hand reaction. These reports have received support from more recent studies (Lyon et al. 1975; Smith, Tong, Leigh 1977). West and Jarvis (1986) reported that nasal administration of nicotine increases tapping rate in nonsmokers.

Tremor

Lippold, Williams, and Wilson (1980) recorded finger tremor during a control period, sham smoking, or cigarette smoking with a strain gauge and an accelerometer. Smoking increased tremor amplitude at least twofold.

Simple Reaction Time

Cotten, Thomas, and Stewart (1971) investigated the immediate effects of smoking one cigarette on simple reaction time after each subject smoked a cigarette with a 1.5-mg nicotine yield. The mean reaction times immediately following and 5 min after smoking were significantly slower than for all other test intervals. Reaction times for the 40- and 55-min intervals were significantly faster than the reaction time before smoking.

Morgan and Pickens (1982) examined whether reaction time performance after smoking varied as a function of cigarette smoking. Twelve regular smokers were tested on a reaction time task immediately after smoking on three different occasions. In each session, they were allowed ad libitum smoking of their own cigarette, or ad libitum smoking of a standard cigarette, or they had to smoke a standard cigarette with a prescribed puff pattern. Reaction time performance was significantly faster after smoking under the latter two of the three conditions. Mean reaction times were significantly shorter for the smokers smoking than for the smokers not smoking.

Choice Reaction Time

Myrsten and Andersson (1978) compared the effects of smoking for both simple and complex reaction time tasks. In the simple reaction time testing periods, smoking prevented the significant increase in reaction time that occurred over time in the nonsmoking condition. In the complex reaction time periods, smoking significantly reduced reaction time, whereas reaction time increases were not significant in the nonsmoking condition.

Decision time and motor time scores on a choice reaction time task were measured after smoking (Lyon et al. 1975; Smith, Tong, Leigh 1977). Decision time scores were significantly decreased by smoking, and the high-nicotine cigarette had the greatest effect. Motor time scores were not improved, and hand steadiness was significantly impaired by smoking.

Smokers, deprived smokers, and nonsmokers performed a compensatory tracking task while simultaneously performing a cross-adaptive loading task (Schori and Jones 1975). With the cross-adaptive technique, the size of the subject's total work load (tracking and loading tasks combined) was individually tailored to use each subject's entire attentional capacity. No differences were detected as a function of smoking either in tracking or in loading task performance.

Smokers, deprived smokers, and nonsmokers performed a complex motor task, consisting of five subtasks, for an extended period of time at two levels of task complexity (Schori and Jones 1974). On only one subtask, on one of the two performance measures obtained, were differences as a function of smoking condition evident. Specifically, response latencies for nonsmokers were shorter than those for smokers and deprived smokers at the high level of task complexity, but were longer at the lower level. Because the performance differences were small, Schori and Jones (1974) concluded that for all practical purposes, smoking had no effect on performance.

Implications for Tobacco Use

Some cigarette smokers report that smoking helps them to think and perform. Laboratory studies of attention and state-dependent learning are generally consistent with this perception, but studies of memory and learning do not support this perception. Data on problem solving are too limited to allow clear conclusions. The improvement in attention, state-dependent learning, and some motor performance tasks are, in most cases, superior in smokers who are allowed to smoke compared with a smoking abstinence condition. Therefore, these effects may, in part, reflect reversal of the deleterious effects of smoking abstinence. In contrast to this cautious interpretation, however, it should be noted that the experiments that administer nicotine and report similar improvements in nonsmokers and smokers are consistent with the interpretation that smoking improves some cognitive performance. In light of these data, smokers' self-reports and perceptions may be correct that smoking helps them to attend, think, and perform. However, until more careful investigations are reported, conclusions concerning the effects of smoking and nicotine on human performance must remain tentative. Future studies should include nonsmokers as controls and should measure nicotine levels after smoking or abstinence.

Current methods in cognitive psychology indicate that different paradigms for evaluating memory and performance (e.g., data-dependent versus context-dependent memory measures) produce opposite effects in many cognitive tasks (Richardson-Klavehn and Bjork 1988). The effects of smoking and nicotine on these different types of tasks need to be evaluated. A recent presentation on smoking and performance, for example, reported that smoking improved performance on simple reaction tasks but impaired performance on more complex comprehension and motor performance tasks (Spilich 1987). Tasks requiring different levels of demand must be examined. Moreover, future research should evaluate performance over time to determine whether any short-term effects of smoking or nicotine on performance persist or are reversed later on. Nonetheless, the fact that smokers smoking generally perform better on some cognitive tasks (especially attention tasks) than do smokers not smoking may encourage smokers to continue smoking and may encourage relapse.

Tobacco Use, Nicotine, Stress, and Mood Regulation

Cigarette smokers commonly report that they smoke in response to stressful situations and that smoking calms them. In addition, many smokers report that smoking helps to regulate dysphoric mood or affect. Reports of a relationship between stress and smoking generally have been regarded as puzzling in light of the sympathomimetic effects (i.e., sympathetic nervous system (SNS) activating actions) of nicotine, but the consistency of these claims has brought research attention to these topics. The possibility that smoking may help to regulate dysphoric moods that involve low arousal states is easier to understand. This Section reviews the relevant research literature and presents current thinking to help explain these phenomena.

Subjective Well-Being, Stress, and Mood Regulation

The state of subjective well-being is construed as one in which positive affect (pleasure, happiness) is high and negative affect (frustration, anger, tension) is low (Watson and Tellegen 1985). Departures from an optimal state may occur because of internally generated affect (worry, anxiety) or through environmental events that strain the coping ability of the individual (Dohrenwend and Dohrenwend 1981). A state of subjective stress is postulated to be a joint function of the current environmental demands and the current coping abilities of the individual (Lazarus and Launier 1978; Lazarus and Folkman 1984). When demands exceed coping ability, a state of subjective stress may arise that manifests at the psychological level as symptoms of psychological distress and at the physiological level as changes in (SNS) arousal, changes in endocrine systems, and decrements in specific task performance (Baum, Grunberg, Singer 1982; Cohen, Kamarck, Mermelstein 1983). In natural settings, stress may occur because of discrete events that cause a transient peak in subjective distress or in conditions that persist over considerable periods of time and thus present sources of chronic strain to affected individuals (Pearlin and Schooler 1978; Pearlin et al. 1981).

Overall mood states are related to independent contributions by dimensions of positive affect and negative affect: well-being is determined by low negative affect and by high positive affect (Diener 1984). Studies of mood states in natural settings over intermediate time periods of 1 day to 1 week show that the dimensions of negative and positive mood are independent, that is, they both occur on a regular basis in daily life and both contribute to overall mood states (Stone, Helder, Schneider 1987). Mood may be regulated both by reduction of negative affect and by increase of positive affect (Tomkins 1962, 1963; Wills and Shiffman 1985).

Subjective well-being could be improved through reducing the perceived environmental demands, through physiologically influencing stress-related arousal states, through reducing perception of unpleasant physical states, or through altering the balance of positive/negative affect in daily life. These mechanisms are relevant to understanding the relationship between stress and cigarette smoking (Tomkins 1965).

Perceived Functions of Smoking

A number of epidemiological studies have examined the perceived functions that smoking provides for users by employing large samples that are usually representative of communities; in some cases, representative national samples have been obtained. These studies ask respondents about various functions that smoking is perceived to provide for them, and the researchers aim to determine basic functional dimensions through factor analysis or cluster analysis of the motive reports. The questionnaire items used to elicit smoking functions vary considerably, including items that elicit agreement/disagreement with statements about smoking, items that elicit the frequency or likelihood of smoking in defined situations, or items that ask about a desire to smoke in certain settings. Although the methodology and sampling procedures have varied considerably across studies, there is consistency in the results. One higher order domain of intercorrelated motive dimensions indicates that smoking is perceived to provide *negative affect reduction*; another domain indicates that smoking is perceived to provide *positive affect enhancement.* Findings from the relevant studies, classified in terms of these higher-order domains, are presented in Table 1. (Survey studies also indicate that many smokers report that smoking keeps weight down and that weight control is one of their major concerns (Charlton 1984a,b; Feldman, Hodgson, Corber 1985; Page 1983). However, for purposes of expositional clarity, this Section focuses on affect regulation and stress. Smoking and body weight are discussed in the next Section of this Chapter.)

A typical study of perceived functions was conducted in the United States by Ikard, Green, and Horn (1969) with a representative national sample of 2,094 adult respondents. In this study, subjects were presented with a list of 23 statements about smoking, representing various combinations of situation and emotion and were asked to indicate their agreement or disagreement about whether the statement was true for them. Orthogonal factor analysis of the items indicated that six basic motives were represented in the data. A factor termed "Reduction of Negative Affect" was loaded by items such as "When I feel upset about something, I light up a cigarette" and "Few things help better than cigarettes when I'm feeling upset." The domain of positive affect enhancement was represented by a factor dimension termed "Pleasurable Relaxation," which included items such as "Smoking cigarettes is pleasant and relaxing." This factor was not correlated with any of the other five factors found in the study, indicating that it is an independent functional dimension. A factor concerning addictive smoking, which included items reporting a strong desire or craving for cigarettes, was substantially correlated with the negative affect factor and for that reason is included under the domain of negative affect reduction.

Other studies of smoking motives have replicated the two domains of negative- and positive-affect regulation. Under the general domain of negative affect reduction, McKennell (1970) surveyed a representative national sample of 1,140 adolescents and adults in Great Britain and found that three factors termed "Nervous Irritation Smoking," "Smoking Alone," and "Food Substitution" were strongly intercorrelated, all representing an increased probability of smoking during unpleasant states. Coan (1973) and Leventhal and Avis (1976), in studies with college students, found almost identical factors termed "Negative Affect Reduction" and "Anxiety Reduction," which in each case were substantially correlated with another factor representing addictive smoking. Additionally, Coan (1973) found a factor termed "Distraction," which included items suggesting that smoking was sometimes used as a means of diverting attention from disturbing stimuli. (This self-report is consistent with the discussion of distraction studies presented in the first Section of this Chapter.) Best and Hakstian (1978) surveyed a sample of 331 adult commuters with an inventory about the relative strength of their urge to smoke in each of 63 situations. Intercorrelated dimensions termed "Nervous Tension," "Frustration," "Embarrassment," "Discomfort,"

TABLE 1.—Summary of studies of perceived functions of smoking

Domain/Factors	Ikard et al. (1969)	McKennell (1970)	Coan (1973)	Leventhal and Avis (1976)	Best and Hakstian (1978)	Baumann and Chenoweth (1984)
Negative affect reduction	Negative affect reduction	Nervous irritation	Negative affect reduction	Anxiety reduction	Nervous tension	n.a.[1]
	Addictive smoking	Food substitution	Addiction	Addiction	Frustration	
		Smoking alone	Distraction		Discomfort	
			Agitated state		Anger/Impatience	
					Restlessness	
Positive affect enhancement	Pleasurable relaxation	Relaxation	Pleasurable relaxation	Pleasure/Taste	Relaxation	Pleasure
		Social confidence smoking	Dependence on mental state			
			Sensorimotor pleasure			
Other functions	Habitual smoking		Habitual action	Habit	Automatic smoking	Habit
	Stimulation	Activity accompaniment	Stimulation	Stimulation	Sensory stimulation	
	Sensorimotor manipulation		Concentration	Fiddling	Concentration	
		Social smoking		Social reward	Social smoking	Positive peer relationships
			Unpleasant habit		Inactivity/Boredom	
					Time structuring	

NOTE: Factors of comparable content are on the same line.

[1] n.a. = factors not available because relevant items not in study.

"Restlessness," and "Anger/Impatience" all indicated elevated rates of smoking in different types of negative affect situations.

Under the domain of positive-affect enhancement, findings are less consistent because studies typically included relatively few items on pleasurable aspects of smoking. Despite this methodological limitation, each of the studies contains one or two factors that represent a function of smoking to produce positive affect. A factor termed "Pleasurable Relaxation" found by Coan (1973) indicated smoking in circumstances that were relaxed and comfortable, and comparable factors termed "Pleasure" were found among adults (Leventhal and Avis 1976) and adolescents (Baumann and Chenoweth 1984). In each case, these dimensions were uncorrelated with negative affect factors or with other dimensions found in the study. Factors that were termed "Relaxation" by two investigators (Best and Hakstian 1978; McKennell 1970) represent smoking in conditions where one is alone or wants to cheer up.

The studies have indicated some additional functional dimensions not included within the two affective domains. Some dimensions represent habitual or automatic smoking that occurs without conscious attention. These self-reported dimensions are consistent with the data presented in Chapter IV that address compulsive drug-seeking properties of nicotine and tobacco use. Another common dimension represents smoking to increase stimulation, typically in conditions of inactivity or boredom; sometimes another dimension is included, indicating that smokers report that smoking helps improve concentration (Best and Hakstian 1978; Coan 1973; Leventhal and Avis 1976). This latter perceived effect is discussed in detail in the first Section of this Chapter. Dimensions representing smoking in social situations indicate that smoking occurs primarily at parties or social gatherings, and these factors typically are uncorrelated with affective dimensions.

With regard to individual differences in motives for smoking, there are some consistencies across studies. Amount of smoking tends to be greater for persons scoring high on negative affect reduction (Ikard, Green, Horn 1969; McKennell 1970), although persons scoring high on habitual smoking may have a greater frequency of smoking (Ikard, Green, Horn 1969; Leventhal and Avis 1976). Sex differences are sometimes found in functional dimensions, with females scoring higher on negative-affect reduction (Frith 1971; Ikard, Green, Horn 1969; Ikard and Tomkins 1973), whereas males score higher on habitual, relaxation, or stimulation smoking (Frith 1971; Ikard, Green, Horn 1969; McKennell 1970). Findings on external correlates of motive dimensions indicate that adolescents who score high on the Pleasure dimension are more likely to initiate or increase smoking over time (Baumann and Chenoweth 1984), and adult smokers who score high on Negative Affect reduction are more likely to relapse after smoking cessation treatment (Pomerleau, Adkins, Perstchuk 1978).

McKennell (1970) found 65 to 75 percent of adults reporting that they perceived smoking to reduce nervous irritation, and comparable levels of endorsement were found for other dimensions of negative- and positive-affect regulation factors. Some data indicate that endorsement rates for habitual, stimulation, sensorimotor manipulation, and social confidence smoking are low in absolute terms (Ikard, Green, Horn 1969; McKennell 1970). A study of young children (Eiser, Walsh, Eiser 1986) found that mood regulation effects of smoking were clearly perceived by subjects in the 7- to 8- and 10- to 11-year-old age ranges; this suggests that perceived functions of smoking may be learned partly by observation rather than through direct experience.

The conclusion from this literature is that in the general population, persons perceive that smoking has functions that are relevant for mood regulation. Persons report that they smoke more in situations involving negative mood, and they perceive that smoking helps them to feel better in such situations. Additionally, smoking is perceived to increase positive mood in some situations. These data do not necessarily indicate that the various functions characterize different types of smokers; rather, they suggest that most functions are salient to an individual but are operative at different times or in different situations. Similar to the discussion of smoking and performance in the first Section of this Chapter, self-reports by smokers that they smoke under stress may indicate direct effects of smoking and nicotine or may reflect effects of smoking deprivation that are relieved by smoking. Whichever interpretation is correct, individuals certainly report that stress is associated with smoking.

Stress and Smoking

There is evidence that stress can increase the likelihood of initiation of smoking if cigarettes are available. Further, considerable evidence exists to link negative-affect states to smoking behavior. The database includes studies of stress as a risk factor for smoking initiation during adolescence and studies on stress and rates of smoking among adults.

Stress and Smoking Initiation

Several studies have shown stress to be related to the onset of smoking in early adolescence. Studies of smoking initiation typically survey a large sample of adolescents beginning at approximately 12 years of age, because the onset of cigarette smoking is greatest during the junior high school period (Fishburne, Abelson, Cisin 1980; Green 1979). Measures of psychosocial risk factors are obtained from questionnaire scales, and indices of smoking status are usually obtained from self-report by respondents, sometimes accompanied by a biochemical index of smoking. There is evidence indicating that self-reports of smoking by adolescents are generally accurate, although the accuracy of self-report data may be increased by administration of biochemical measures (Murray et al. 1987). Convergent results from cross-sectional and prospective studies show that stress is antecedent to substance use onset and is not a consequence of the initiation of smoking (Gorsuch and Butler 1976; Kandel 1978; Kandel, Kessler, Margulies 1978; Kaplan et al. 1986).

The most direct evidence linking smoking to negative mood states is based on measures of subjective stress. A cross-sectional study by Mitic, McGuire, and Neumann (1985) surveyed a random sample of 1,684 school students in grades 7 through 12 in a medium-sized Canadian community and obtained measures indexing whether students felt nervous, anxious, or worried as a result of 12 potential problem areas. Analyses for the total sample indicated that regular and heavy smokers scored higher on perceived stress, compared with nonsmokers. A related study by Hirschman, Leventhal, and Glynn (1984) employed as the criterion variable a retrospective report of smoking experiences during the previous 2 years. Data were obtained from a stratified sample of 386 students in grades 2 through 10 in a midwestern community. Analyses of data on smoking transitions indicated that a measure of affective distress was related to rapid transitions from experimental to regular smoking. These results were obtained in multivariate analyses with control for other variables including age, peer and parental smoking, and risk-taking tendency.

Comparable findings occurred in a prospective study by Wills (1985, 1986) of a population sample of 675 students in the 7th grade in a New York City school district. Analyses for a 14-item scale of subjective stress reactions showed that high stress was related to increased levels of smoking over a 2-year period. Additional data from this cohort and a replication cohort of 901 students were obtained with measures of everyday negative events and major life events. Multivariate analyses of these data indicated that all three measures of stress were related to smoking, with major negative events being the statistically strongest predictor. These analyses indicated that the effect of stress on smoking was not attributable to other variables including sex, race, locus of control, self-esteem, social activity, and assertiveness. These findings are consistent with laboratory data indicating that females under stress are more willing to try additional cigarettes after an initial smoking experience (Silverstein et al. 1982).

It should be noted that adoption of cigarette smoking has been shown to be a risk factor for subsequent adoptions of other types of